

BeCrop Trials 4.0 Guide

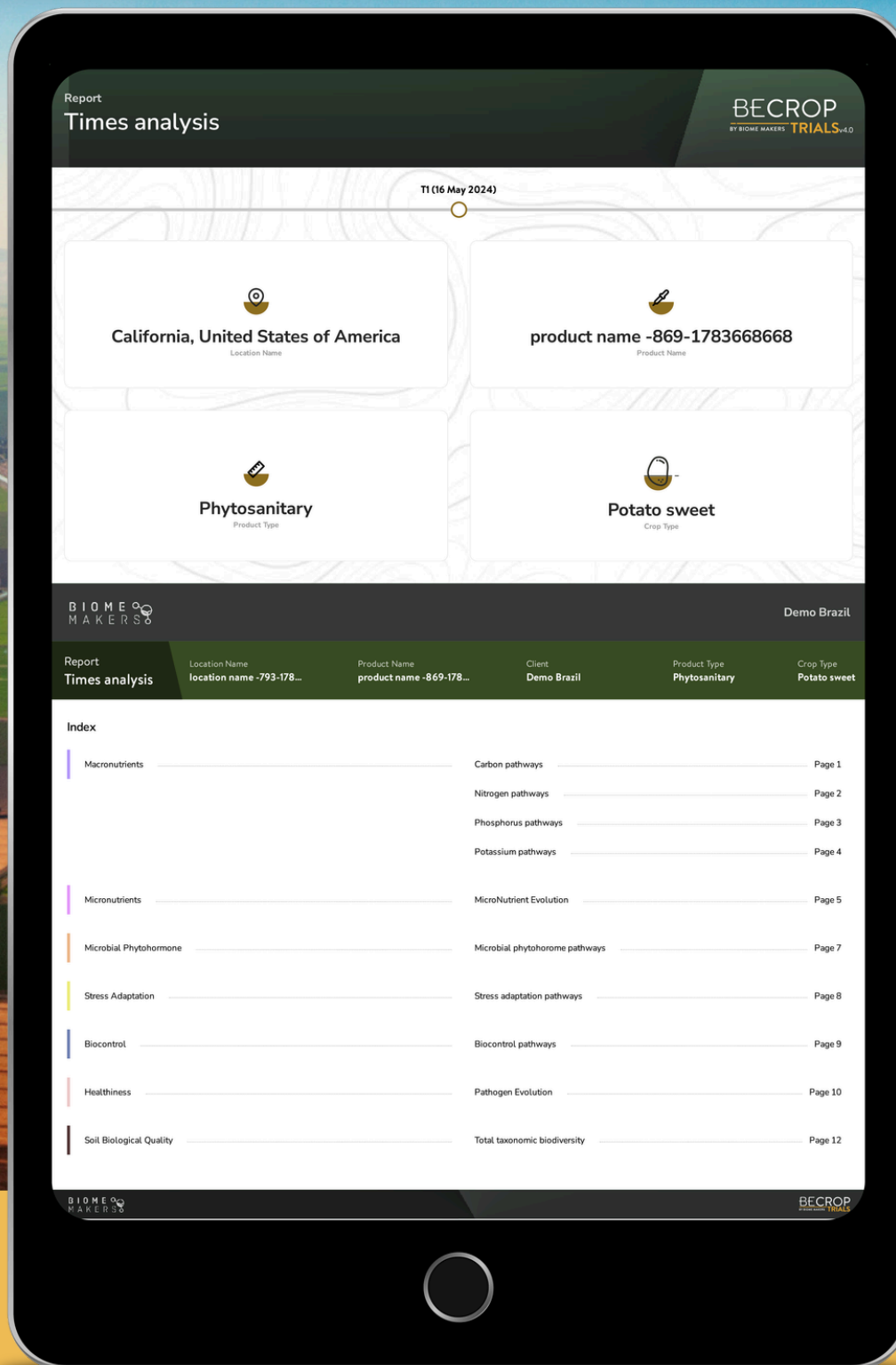


Table of Contents

Executive Summary & Scientific Rationale	03
Experimental Design: The Foundation of Rigor	04
The Statistical Framework: Significance vs. Magnitude (Fold Change)	06
Metabolic Pathways in Crop Nutrition	08
Health: Phytohormones, Stress Adaptation, Biocontrol & Pathogen Evolution	11
Soil Biological Quality Indicators	14
Translating Science into Value	15
Annex. Scientific References & Public Examples	17

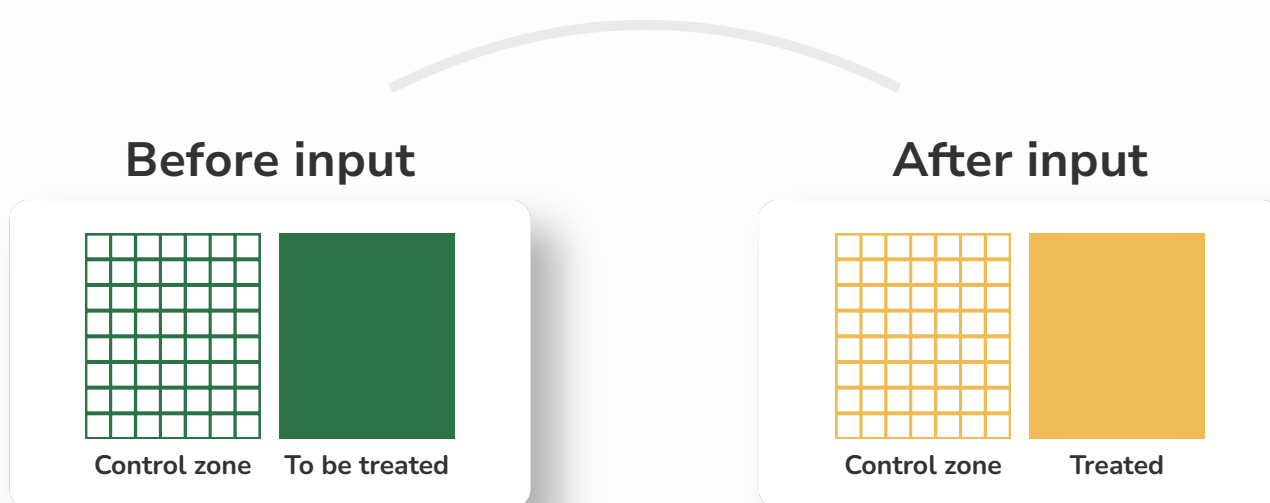
1. Executive Summary & Scientific Rationale

In modern sustainable agriculture, manufacturers of biological inputs, crop protection products, and specialized fertilizers face a highly crowded and competitive marketplace. Traditional soil chemical testing provides an indispensable but static overview of nutrient presence, yet it fails to capture the living engine of the soil: the microbiome. The soil microbiome is responsible for nutrient cycling, plant hormone production, and natural disease suppression. Therefore, to truly validate the efficacy and the biological impact of an agricultural product, program, or management practice, a dynamic, functionally focused methodology is required. BeCrop Trials 4.0 represents the global benchmark for advanced field validation, enabling agriscience companies to look directly into the functional soil microbiome and measure how specific treatments interact with biological pathways.

By leveraging Next-Generation Sequencing (NGS) and proprietary ecological computing algorithms, BeCrop Trials moves far beyond observational biology. This comprehensive guide serves as the definitive manual for R&D directors, product managers, and agronomic advisors to understand, interpret, and leverage BeCrop Trials reports, ensuring that complex biological data is successfully converted into verifiable commercial value.

2. Experimental Design: The Foundation of Rigor

The validity of any field trial stands or falls on its experimental design. Because the soil microbiome is a living ecosystem, it is naturally subjected to high spatial heterogeneity and micro-environmental fluctuations. A poorly constructed trial will produce confounding data where natural background variation masks the true performance of the product. BeCrop Trials 4.0 enforces a strict, scientifically validated experimental layout designed to filter out environmental noise and isolate the precise impact of the treatment.



2.1 Sample Rule and Replicate Recommendations

To establish statistical confidence and calculate reliable probability values (p-values), BeCrop Trials projects requiring an absolute minimum of 12 soil samples. Sampling less than this threshold eliminates the mathematical basis required to separate random variation from genuine treatment effects. Within each sample group, a minimum of 3 biological replicates is strictly mandated. These replicates must be collected from distinct zones within the same treatment plot to account for natural localized variations in soil texture, moisture, and root density. By combining these 3 replicates per group, the BeCrop engine can mathematically smooth out localized anomalies and deliver an accurate representation of the plot's biological profile.

2.2 Spatial Dynamics: The Critical Role of Locations

An input's performance is rarely uniform across different geographic regions. Factors such as soil type (sandy vs. clay), organic matter content, baseline pH, and regional climatic conditions heavily influence how the native soil microbiome responds to an applied treatment. Testing a product in only a single location creates a significant commercial risk, as the results may not be reproducible elsewhere.

Biome Makers strongly recommends deploying BeCrop Trials across multiple strategic locations. This spatial diversity allows manufacturers to discover the environmental boundaries of their product, establishing exactly which soil types and climates maximize its efficacy and which conditions limit its performance.

2.3 Temporal Dynamics: The Importance of Time Points

Microbial communities are highly dynamic and operate on distinct temporal scales following a product application. A single post-treatment snapshot is insufficient because biological effects evolve over time. For example, a bioestimulant might trigger a massive, immediate bloom of beneficial bacteria within the first 14 days, which then stabilizes into a long-term functional shift by day 60. Conversely, a controlled-release fertilizer might show its peak biological impact several months after application. BeCrop Trials requires at least two distinct time points: Time 0 (T0), establishing the baseline before application, and Time 1 (T1), capturing the post-treatment effect. For advanced research, tracking multiple subsequent time points (T2, T3) is highly recommended to determine the longevity and residual stability of the product's biological passport.

2.4 The Imperative of Control Plots: Isolating the Treatment Effect

The most critical component of a scientifically sound agronomic trial is the absolute inclusion of untreated Control plots at every single location and time point. It is mathematically impossible to isolate the effect of a product without a direct, side-by-side comparison against an untreated baseline over time. Throughout the course of a field trial, the soil microbiome is continuously altered by external macro-factors such as rainfall events, temperature shifts, crop growth stages, and tillage. If an agronomist only samples a treated plot at T0 and T1, any observed increase in a pathway (such as Nitrogen fixation) could simply be the result of a recent rain or seasonal warming, rather than the product itself.

By maintaining a parallel Control group (T0 Control, T0 Treated, T1 Control, and T1 Treated), BeCrop Trials isolates external environmental variables. If both the Control and Treated plots experience an increase due to weather, but the Treated plot shows a significantly higher magnitude of change, the BeCrop engine can successfully isolate and credit that additional benefit directly to the agricultural input. This dual-control architecture is what elevates BeCrop Trials from a descriptive observation to an unassailable scientific proof.



3. The Statistical Framework: Significance vs. Magnitude (Fold Change)

BeCrop Trials 4.0 does not merely report numerical increases or decreases; it subjects every single biological shift to a rigorous statistical validation using mathematical models.

- ① Beta regression: models are fit to each BeCrop index. Models take into account a full factorial design where all time, treatment and location combinations are present.
- ② Model quality check explainability through Akaike Information criterion.
- ③ Treatment comparisons: uses estimated marginal means to compare treatments against the control/reference group. the comparison is performed through **delta-delta** approach which corrects the baseline at T0.
- ④ Multiple-testing correction: p-values resulting from treatment comparisons are adjusted using the FDR (False Discovery Rate) method, to avoid false positives when testing many indices at once.

This ensures that manufacturers only make commercial claims based on reliable, reproducible data. However, it is essential to understand that the report measures two distinct but complementary parameters: Statistical Significance (p-value) and Magnitude of Change (Fold Change).

3.1 Magnitude of Change (Fold Change)

CATEGORY	SUB-SUBCATEGORY	METRIC	FOLD CHANGE
Biological soil quality	Biological soil quality	Fungal taxonomic biodiversity	43.0% ** (PE)
Biological soil quality	Biological soil quality	Soil biostability	25.0% ** (PE)
Biological soil quality	Biological soil quality	Bacterial taxonomic biodiversity	-14.0% ** (AE)
Diseases and biocontrol	Diseases	Sclerotial Blight (Southern Blight)	3.0%
Nutrition	Manganese (Mn)	Manganese transport equilibrium	-22.0% ** (AE)
Microbial phytohormone prod. and stress adapt.	Microbial phytohormone prod.	Cytokinin production	-22.0% ** (AE)
Nutrition	Carbon pathways (C)	Fermentation	-15.0% ** (PE)
Nutrition	Carbon pathways (C)	Carbon fixation	33.0% ** (PE)
Nutrition	Carbon pathways (C)	Methanogenesis	26.0% ** (AE)

While significance tells us if a change is statistically reliable, the Fold Change tells us how large that change actually is. The Fold Change is presented as a percentage (%) of the difference between the values representing the changes caused by product application of the reference time T0 and the evaluated time Tx. For example, a Fold Change of +100% indicates a 2x (twofold) increase in that pathway compared to the differences between Treated/Control obtained in T0 versus evaluated time Tx. Based on extensive global observations, changes of +100% or greater are considered substantial and biologically important shifts in the ecosystem.

3.2 Statistical Significance (Significance Codes)

Significance represents the mathematical confidence that the observed Fold Change is due to the treatment and not random environmental noise. Crucially, the probability of achieving statistical significance is directly proportional to the number of samples and replicates. The more samples included in the trial, the higher the statistical power to validate even subtle functional changes.

Every functional pathway in the report is assigned a specific significance code based on its calculated p-value:

Legend									
Positive Effect** (PE)	●	Positive Trend* (PT)	●	Major Change (MC)	●	Adverse Trend* (AT)	●	Adverse Effect** (AE)	●
Positive change with statistical support of p-value <= 0.1		Positive change with statistical support of 0.1 < p-value <= 0.3		Positive change with statistical support of 0.3 < p-value <= 0.5		Negative change with statistical support of 0.1 < p-value <= 0.3		Negative change with statistical support of p-value <= 0.1	

Changes with p-value > 0.5 are indicated in gray and with - if there is no output.

Metric Nature: Beneficial vs. Harmful Indexes

Every BeCrop index reflects a specific type of microbial action, and this nature must be considered when interpreting the direction of a Fold Change. Depending on the ecological role of the underlying pathway, BeCrop indexes fall into one of two categories: Harmful metrics, which represent an undesired action of the microbial community against soil health or the soil ecosystem, and Beneficial metrics, which represent a positive action for the soil.

Correctly interpreting a Fold Change requires combining its direction — an increase (positive value) or a decrease (negative value) — with the nature of the metric it applies to:

- **Fold Change is beneficial** when it shows an increase in a Beneficial metric, or a decrease in a Harmful metric.
- **Fold Change is harmful** when it shows a decrease in a Beneficial metric, or an increase in a Harmful metric.

BeCrop® metric changes:

BeCrop® increase ↑

Indicate benefits in soil when the metric rises.

BeCrop® decrease ↓

Indicate benefits in soil when the metric decreases.



Significance Code	Statistical Definition	Agronomic Interpretation
PE (Positive Effect)	$p\text{-value} \leq 0.1$	Highly significant improvement. The treatment has definitively enhanced this specific microbial pathway compared to the control.
PT (Positive Trend)	$0.1 < p\text{-value} \leq 0.3$	Moderate positive shift. Indicates a clear directional improvement, though slightly less statistically rigid. Highly useful for early-stage R&D.
MC (Major Change)	$0.3 < p\text{-value} \leq 0.5$	Profound structural or compositional alteration in the ecosystem. Requires contextual agronomic evaluation to determine its benefit.
AT (Adverse Trend)	Moderate negative shift	An observable decline in the pathway relative to the control, signaling a potential undesirable side effect of the management practice.
AE (Adverse Effect)	Significant negative shift	Statistically significant suppression or worsening of the pathway, indicating that the treatment has actively disrupted this specific biological function.
0%	No statistical change	The pathway remains completely unchanged, indicating that no change was measured; this is not evidence that the product had no effect.
---	Insufficient data	There is not enough data or statistical evidence to support any conclusion: positive, negative, or null.

4. Metabolic Pathways in Crop Nutrition

For manufacturers of biofertilizers, biostimulants, and traditional nutritional inputs, this section acts as the ultimate verification of nutrient mobilization efficiency, showing exactly how a product unlocks unavailable soil reserves.

Carbon Pathways

Carbon is the basis of biological soil fertility. It is the main compound in organic matter and an essential source of food for beneficial soil microbes. The presence of organic carbon improves soil health and fertility, increasing crop yields and reducing soil degradation. A low value indicates potential for carbon loss from the soil, while high values indicate potential for carbon sequestration.

Gain

CARBON FIXATION

The conversion process of inorganic carbon to organic compounds by living microorganisms.

ORGANIC COMPOUNDS DEGRADATION

The process in which soil microorganisms decompose vegetal debris, releasing diverse mineral nutrients. It is related to soil humification.

Loss

AEROBIC RESPIRATION

The process in which microbes use organic compounds in oxygenated conditions, releasing CO₂

FERMENTATION

The process in which cells gain energy from organic compounds in non-oxygenated conditions, releasing CO₂

METHANOGENESIS

The formation of methane (CH₄) by microbes, contributing to the degradation of organic matter. Typically in anoxic conditions.

Nitrogen Pathways

Nitrogen is a major component of plant DNA, proteins, and chlorophyll, playing a fundamental role in crop yield. The mineralization of organic to inorganic nitrogen, fixation of atmospheric nitrogen, and process of nitrification by microorganisms supplies N in readily available forms (nitrate and ammonia) for plants. Low values indicate low nitrogen mobilization potential by microbes.



Gain **NITROGEN FROM GAS**

Nitrogen fixation, or the microbial transformation of atmospheric nitrogen into forms that plants and soil microbes can use.

NITROGEN TO AMMONIA

Nitrogen mineralization, or the microbial transformation of organic nitrogen into inorganic forms (ammonia).

NITROGEN TO NITRATE

Nitrification, or the microbial conversion of intermediate nitrogen forms to nitrate that plants can use.

Loss **NITROGEN TO GAS**

Denitrification, or the microbial conversion of nitrate into nitrogen gas that is lost to the atmosphere.

UREA BY VOLATILIZATION

Nitrogen volatilization, or the microbial conversion of urea to nitrogen gas that is lost to the atmosphere.

NITROGEN TO BIOMASS

Immobilization, or the microbial conversion of inorganic nitrogen compounds to organic forms in microbial biomass.

In BeCrop Trials, Nitrogen Pathways enable detailed evaluation of microbial nitrogen fixation, nitrification, and denitrification in response to a treatment. A Positive Effect (PE) in nitrogen fixation provides strong evidence that the treatment enhances the microbial potential to supply biologically available nitrogen, supporting reduced dependency on synthetic nitrogen inputs when interpreted alongside agronomic performance and field observations.

Phosphorus Pathways

Phosphorus is a fundamental nutrient required in the regulation of protein synthesis and plant growth. It enhances the development of roots, while its deficiency leads to stunted growth, dark purple color of leaves, and inhibition of flowering. Low values indicate that the microbial processes that make phosphorus available for plants are low.

Nutrient Supply **INORGANIC PHOSPHORUS SOLUBILIZATION**

Certain soil microorganisms are capable of dissolving insoluble phosphorus from minerals and rocks. They convert insoluble phosphorus in the soil into a form that plants can access, improving their growth and yield. Major portions of conventional phosphorus fertilizers applied to fields end up locked in this insoluble form, so higher levels of phosphorus solubilizing microbes can improve phosphorus fertilizer use efficiency.

Nutrient Competition **INORGANIC PHOSPHORUS CONSUMPTION**

Both plants and microbes require phosphorus to support their metabolic functions. High values indicate high competition/immobilization of phosphorus by soil microbes.

PHOSPHORUS SOLUBILIZATION AND MINERALIZATION

Evaluates the specific microbial pathways responsible for converting locked inorganic phosphorus (via solubilization) and organic phosphorus (via mineralization) into orthophosphates that the plant root can easily absorb.

Potassium Pathways

Potassium is a regulator of metabolic activities, especially those involved in producing proteins and sugars and regulating crop evapotranspiration. When bioavailable potassium is deficient it causes leaf curl and sensitivity to droughts. Low values indicate that the microbial processes that make potassium available for plants are low.

Nutrient Supply ↗

POTASSIUM EXPORT

Certain soil microorganisms export potassium ions from inside their cells to the surrounding environment, making them more available for plant uptake, improving their growth and yields.

Nutrient Competition ↘

POTASSIUM CONSUMPTION

Both plants and microbes require potassium for their functioning. High values indicate a high potential for microbes to compete with the plant by assimilating this nutrient.

Tracks specialized transport mechanisms and pathways, including organic acid production for potassium release and siderophore synthesis for iron and zinc capture, validating high-efficiency uptake claims.



Minor Nutrients

Elements with less influence on the crop's nutritional status yet still serve important roles in plant growth and development.



IRON (Iron Mobilization)

Iron is abundant in most soils but is often present in forms that are not readily available to plants. This metric evaluates microbial functions associated with iron mobilization and assimilation. Medium to high values indicate a sufficient microbial potential to support iron availability.



CALCIUM (Calcium Transport)

Calcium plays an important role in nutrient assimilation, soil structure, and plant development. This metric evaluates microbial functions associated with calcium transport. Higher values indicate a greater microbial potential to support calcium movement and soil stability.



ZINC (Zinc Transport Equilibrium)

Zinc is an essential micronutrient involved in enzyme activity, protein synthesis, and hormone production. This metric evaluates microbial functions associated with zinc transport and balance. Medium to high values indicate a sufficient microbial potential to support zinc availability.



COPPER (Copper Export)

Copper is an essential micronutrient involved in plant metabolism and enzyme activity. This metric evaluates microbial functions associated with copper transport and export. Very high values may indicate conditions associated with excess copper in the soil.



MANGANESE (Manganese Transport Equilibrium)

Manganese plays important roles in photosynthesis, respiration, and nitrogen metabolism. This metric evaluates microbial functions related to manganese transport and balance within the soil ecosystem. Medium values are generally considered optimal.



MAGNESIUM (Magnesium Transport)

Magnesium is a key component of chlorophyll and is essential for photosynthesis and nutrient transport. This metric evaluates microbial functions associated with magnesium transport and availability. Higher values are generally favorable.



SULFUR (Sulfur Cycle Equilibrium)

Sulfur is required for protein synthesis and plant metabolism. This metric evaluates microbial functions involved in sulfur cycling and transformation. Medium to high values indicate a balanced sulfur cycle.



CHLORINE (Chlorine Transport)

Chlorine contributes to several physiological processes, including water regulation and stress tolerance. This metric evaluates microbial functions related to chlorine transport. Medium to high values generally indicate balanced microbial activity.

5. Health: Phytohormones, Stress Adaptation, Biocontrol & Pathogen Evolution

This section is crucial for crop protection and biocontrol manufacturers. It evaluates whether a treatment actively suppresses harmful pathogens or recruits the soil's natural biological defenders.

Phytohormone Production

Phytormone producers: microbial species grouped according to their potential to produce phytohormones. Phytohormones are organic compounds synthesized not only by plants, but also by soil microorganisms as part of their interaction with the plant and surrounding ecosystem.

The Hormone Production metric evaluates the microbiome's potential to synthesize plant growth-promoting phytohormones. These compounds, even at low concentrations, can influence plant development, root growth, nutrient uptake, and overall crop performance.

The report evaluates three main groups of phytohormone-related microbial functions:

- **Auxins (IAA)**
- **Cytokinins (CK)**
- **Gibberellins (GA)**

When interpreting these results, it is important to consider the crop's phenological stage, as the relevance of each hormone varies throughout plant development. A low value is not necessarily detrimental and should always be interpreted within the agronomic context of the crop.

Stress Adaptation

Adaptation to stress conditions: Microbial species grouped according to their ability to produce metabolites that help plants withstand stress conditions. The seven considered mechanisms are ACC (1-aminocyclopropane-1-carboxylate) deaminase production, exopolysaccharide production, heavy metal resistance, salt tolerance, siderophore production, salicylic acid, and abscisic acid.

STRESS ADAPTATION

MEDIUM

Metabolite	Functions	
Exopolysaccharide production	Nutrient trap	Salinity protection
Heavy Metal Resistance	Bioremediation	Detoxification
Salt Tolerance	Alleviate Water Stress	Root Growth
Siderophore Production	Iron Nutrition	Biofertilization
ACC deaminase (ACC-D)	Pathogen Protection	Drought Protection
Salicylic Acid (SA)	Alleviate Water Stress	Salinity protection
Absciscic Acid (ABA)	Growth Regulation	Plant Resistance



Stress management mechanisms play important roles in plant growth as they improve the general health status and development of plants. The presence of microorganisms with the ability to produce these stress adaptive substances will improve plant development and crop yield.



Biocontrol

Microbial species are grouped here according to the type of pest or pathogen they can suppress. The four considered groups are fungicides, bactericides, insecticides, and nematicides. These values do not indicate presence of residues in the soil, but of naturally-occurring organisms that help suppress pests or pathogens.

Biocontrol agents could be predatory, parasitoids of pathogen species, or competing for the same ecological niche with them. Based on their level detected, the presence of biocontrol agents indicates potential for natural control of pests and pathogens by beneficial soil microbes. So soils with high-very high values in these biocontrol indexes may not need to rely on heavy applications of plant protection products to control pest or pathogen impacts.

In BeCrop Trials, Biocontrol Pathways enable the evaluation of the stimulation and proliferation of indigenous beneficial microorganisms that produce natural antifungal compounds, bactericidal, insecticidal, or nematocidal activities. A Positive Effect (PE) or Positive Trend (PT) indicates that the treatment enhances the soil's natural biological defenses against pests and pathogens.

Pathogen Evolution

Disease Risk is evaluated using epidemiological information derived from a large database of agricultural samples and the vulnerability of the microbial ecosystem. Risk levels are established according to the likelihood of disease progression associated with detected pathogens.

The risk level is calculated based on the pathogen load, as well as the ecology (biocontrol levels) of the sample. High or very high risk levels indicate a high probability of developing the disease. Low or very low risks do not need immediate action, though they require attention. Unlike other metrics in the report that represent an average value, the disease risk represents the highest level detected across the evaluated field.

Three primary factors drive plant disease development and are commonly referred to as the **disease triangle**: plant phenology, environmental conditions, and the presence or dominance of the pathogen. This metric evaluates the pathogen component of the disease triangle. A high risk does not necessarily mean that disease will occur, but it indicates that one of the key factors favoring disease development is present.

In BeCrop Trials, Pathogen Evolution enables direct monitoring of the relative abundance of economically important soil-borne pathogens, including *Fusarium*, *Phytophthora*, *Rhizoctonia*, and *Verticillium*. Since these indexes are Harmful metrics, a significant decrease (negative Fold Change) indicates successful biological suppression, while a significant increase (positive Fold Change) signals pathogen proliferation and elevated disease risk.

6. Soil Biological Quality Indicators

This section of the report looks at the global structure of the soil ecosystem, examining how the treatment affects the biological community as a whole before diving into specific metabolic pathways.

Soil Biosustainability

This metric provides a single score representing overall soil biological status. It is based on microbial biodiversity, functionality, and network properties (microbial ecology). This index is benchmarked to assess changes in agricultural management practices on overall soil biological status, with lower scores indicative of intensive management, and higher scores indicative of regenerative management.

Total Taxonomic Biodiversity (ITB)

A composite index that quantifies the overall taxonomic diversity of the soil microbiome by integrating data from both the bacteria-archaea and fungi. It captures the breadth and evenness of microbial taxa present in a soil sample, providing a single high-level metric that reflects the ecological complexity of the entire microbial community. Higher values indicate a richer, more balanced microbiome, which is generally associated with greater soil functional resilience and ecosystem stability.

Bacterial Biodiversity (ITB-16S)

An index that measures the taxonomic diversity of the bacterial community in a soil sample, derived exclusively from sequencing of the molecular marker for bacterial and archaeal identification. It reflects the richness (number of distinct taxa) and evenness (relative abundance distribution) of bacteria in the sample. This index is particularly sensitive to disturbances that selectively affect prokaryotic populations, such as the application of bactericidal agents or shifts in soil pH and nutrient availability.

Fungal Biodiversity (ITB-ITS)

An index that measures the taxonomic diversity of the fungal community in a soil sample, calculated from sequencing of the universal barcode marker for fungal identification. It captures the richness and evenness of fungal taxa, including saprophytes, mycorrhizal symbionts, and potential pathogens. This index is especially relevant for assessing soil health in agricultural contexts, as fungal diversity plays a critical role in nutrient cycling, organic matter decomposition, and plant-microbe symbiotic networks.



7. Translating Science into Value

The ultimate goal of BeCrop Trials 4.0 is not merely to generate academic data, but to empower agribusinesses to achieve market success, protect their pricing power, and de-risk their commercial launches.

7.1 Formulating Validated Marketing Claims

Modern growers, retailers, and distributors are increasingly skeptical of generic biological inputs that promise vague benefits like "enhanced vigor" or "improved soil life." BeCrop Trials allows marketing teams to transition from ambiguous rhetoric to precise, scientifically validated functional claims. Backed by rigorous p-values, a company can confidently claim that their product "statistically increases inorganic phosphorus solubilization by 30%" or "demonstrates a proven 45% reduction in baseline Fusarium risk." These quantifiable, certified metrics immediately capture the attention of sophisticated corporate buyers and large-scale agricultural operations.

7.2 Achieving Definitive Product Differentiation

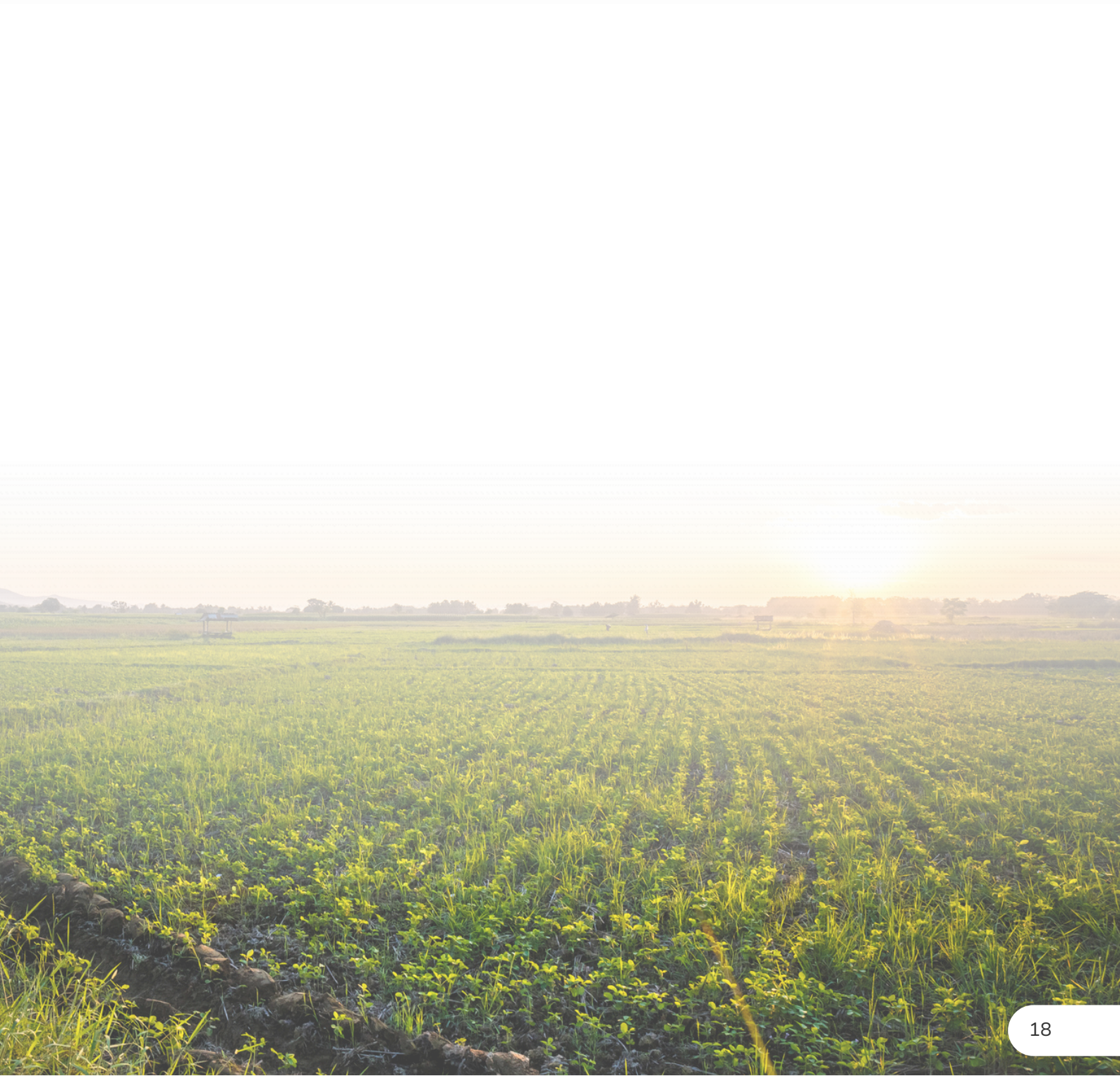
The agricultural input sector, particularly the biostimulant and biofertilizer markets, is highly fragmented and crowded with generic humic acids, seaweed extracts, and microbial cocktails. BeCrop Trials provides a unique "Biological Passport" that acts as an undeniable differentiator. By showcasing the exact metabolic pathways activated by a unique formulation, manufacturers can clearly demonstrate why their premium product outperforms cheaper, generic alternatives on the market, successfully justifying a higher price point and protecting corporate profit margins.

7.3 Strategic Insights for R&D Teams

For research and development departments, BeCrop Trials acts as a molecular diagnostic guide for continuous product improvement. By understanding the precise biological Mode of Action, R&D teams can optimize product formulation, calibrate ideal application dosages, select compatible tank-mix partners, and determine the exact agronomic timing required to maximize microbial establishment. This eliminates costly trial-and-error development cycles and significantly accelerates the product's time-to-market.

7.4 Precision Product Positioning & Data-Driven Recommendations

No agricultural input works perfectly in every single scenario. By cross-referencing BeCrop Trials data across multiple locations and baseline time points (T0), manufacturers can identify the precise environmental conditions where their product delivers the highest return on investment. If the data shows that a biofertilizer achieves a Positive Effect (PE) in high-pH, low-organic-matter sandy soils, but shows no effect in heavy clay soils, the commercial team can hyper-target their sales efforts. This level of precision prevents high-risk applications in unsuitable environments, drastically reduces customer churn, and establishes long-term brand loyalty built on predictable, data-driven field performance.



Annex. Scientific References & Public Examples

The following peer-reviewed publications provide the scientific foundation and public examples supporting the BeCrop® methodology presented throughout this guide. Together, they demonstrate how biological indicators, microbial functionality, and soil microbiome analyses can be applied to evaluate agricultural management practices, biological products, and soil health across diverse cropping systems and environments.

Readers interested in learning more about the scientific principles and real-world applications of BeCrop® are encouraged to consult the following publications.

1. Global validation of microbial network organization as a soil health biomarker

This landmark international study validates microbial network organization as a robust biomarker of soil health across **1,921 soil samples collected from 33 countries**, reinforcing the scientific basis behind the biological indicators and network analyses used throughout the BeCrop® platform.

Reference

Ortiz-Álvarez, R., et al. (2026). *Microbial network organization is a robust biomarker of soil health across global agricultural systems*. **Global Change Biology**.

DOI: <https://doi.org/10.1111/gcb.70984>

2. Evaluating biological product performance using BeCrop®

This multi-location field study demonstrates how BeCrop® can be used to evaluate the impact of a biological product under commercial field conditions. By integrating microbiome analysis with agronomic performance, the study illustrates how biological indicators can support efficacy assessments in agricultural trials.

Reference

Adamo, I., Acín-Albiac, M., Röttgers, S., et al. (2024). *Short impact on soil microbiome of a *Bacillus amyloliquefaciens* QST713-based product that correlates with higher potato yield across USA*. **Frontiers in Plant Science**, 15, 1332840.

DOI: <https://doi.org/10.3389/fpls.2024.1332840>

3. Assessing agricultural management through biological soil indicators

This study compares conventional, transitional, and organic vineyard management systems using BeCrop® biological indicators. The results demonstrate how soil microbiome functionality, nutrient cycling, microbial network organization, and soil biological quality respond to different agricultural management practices.

Reference

Blanco, P., Rodríguez, I., Fernández-Fernández, V., et al. (2024). *Physicochemical Properties and Microbiome of Vineyard Soils from DOP Ribeiro (NW Spain) Are Influenced by Agricultural Management*. **Microorganisms**, 12(3), 595.

DOI: <https://doi.org/10.3390/microorganisms12030595>

4. Monitoring biological responses to biodynamic soil amendments

This multi-location study evaluates the impact of biodynamic preparations on soil microbial communities using BeCrop® biological indicators. The research demonstrates how microbial functionality—including phytohormone production, stress adaptation, and plant growth-promoting microorganisms—can be monitored to assess biological responses under different management strategies.

Reference

Milke, F., Rodas-Gaitan, H., Meissner, G., et al. (2024). *Enrichment of putative plant growth promoting microorganisms in biodynamic compared with organic agriculture soils*. **ISME Communications**, 4(1), ycae021.

DOI: <https://doi.org/10.1093/ismeco/ycae021>



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